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Wood and Energy in Maine

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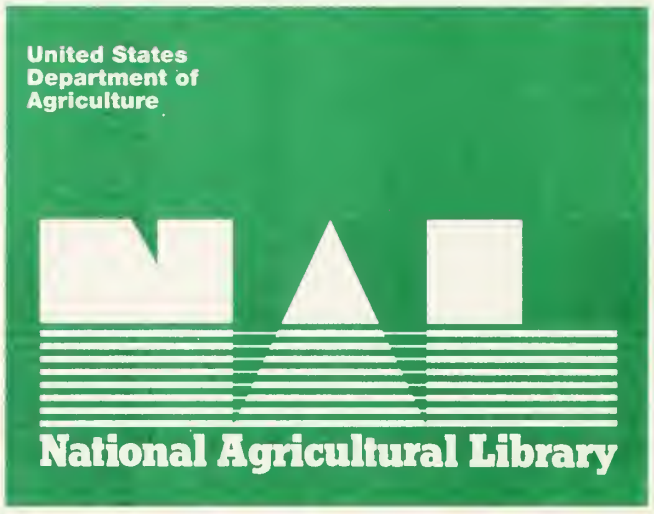
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WOOD AND ENERGY IN MAINE. By Mark R. Bailey and Paul R. Wheeling, Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Washington, D.C. September 1982. ERS Staff Report No. AGES 820817.

ABSTRACT

Telephone surveys of Maine households conducted in 1979 and 1980 indicate a transition to wood heating in response to a series of conventional energy price increases and uncertainty in conventional energy supplies. Maine households consumed 575,000 cords of wood in the winter of 1978-79; 731,000 cords were burnt during the next winter. The airtight wood stove has become the most commonly used wood-burning apparatus. Survey data of residential wood cutting, purchasing, and burning were analyzed by household tenure, wood-burning apparatus, and county. Residential use of wood for energy constitutes a new demand on the forest resource, increases local income and employment, displaces fuel oil and electricity, and may compromise household safety.

Key words: Maine, wood energy, residential energy demand, forest resource, wood-burning stoves, cordwood, fuelwood, renewable energy, energy substitution, New England

OTHER FUELWOOD REPORTS

A report on Wood and Energy will be published for each New England State during the 1982 summer and early fall. Presently, Wood and Energy in Vermont (ERS, USDA Report No. AGES 820126) and Wood and Energy in New Hampshire (ERS, USDA Report No. AGES 820604) are now available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Order by report number and title.

DEDICATION

This report is dedicated to John H. Miner, who from 1976 was the Chief, Resource Conservation and Development Branch of the Soil Conservation Service, USDA. Mr. Miner, who retired from the Service in December 1980, was an ardent supporter of the Resource Conservation and Development Program, and was especially supportive of the New England Fuelwood Study of which this report is a part.

PREFACE

Wood and Energy in Maine is the third of a series of reports stemming from the New England fuelwood study initiated on October 1, 1978 by the Economic Research Service (ERS) at the request of a number of resource conservation and development (RC&D) areas located throughout the region (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut). These RC&D areas wished to have an economic analysis of the feasibility of using wood as an alternative energy source and an estimate of the impacts of wood energy on the State economies. Four objectives were established:

1. Analyze wood energy supply and demand.
2. Determine Btu costs of alternative fuels.
3. Identify and examine present and potential barriers to adoption of wood energy.
4. Examine the economic impact of wood energy adoption upon State economies in New England.

After conducting a literature review (5), the researchers decided to examine only the residential sector because, while there was a growing body of information regarding wood energy used in the commercial and industrial sectors, there was little regionally consistent information regarding residential use of such energy. The study was a highly cooperative effort that included ERS, the RC&D program administered by the Soil Conservation Service (SCS), local RC&D areas, State energy offices, and many other local agencies.

Wood and Energy in Maine presents information on residential use of wood energy obtained from two household surveys. The first survey, conducted in 1979, obtained detailed information from more than 1100 households. The second or followup survey of 588 households, conducted a year later, provided estimates of fuelwood use in the 1979-80 winter, and more information on energy displacement and cordwood purchases (fuelwood is used interchangeably with firewood and cordwood in this report). The Maine surveys confirm that a broadly based transition to cordwood use has occurred in household heating. This energy shift has significantly changed the use of conventional energy and added to demands placed upon forests.

The Maine Office of Energy Resources, Coastal Enterprises, Inc., together with the Threshold to Maine, Time and Tide, and Down East RC&D areas sponsored the 1979 and 1980 Maine surveys using the methodology and questionnaire jointly developed by ERS, representatives from participating RC&D areas, and various State energy offices. The RC&D areas in Massachusetts, Connecticut, and Rhode Island sponsored surveys in their States; the Governor's Council on Energy conducted surveys in New Hampshire; the Vermont Energy Office conducted surveys in Vermont.

The New England fuelwood surveys were conducted under strict guidelines. To insure reliable results, estimation techniques included a carefully prepared questionnaire, a three-way stratification of results, and rigorous testing for seven different forms of response bias. The surveys were conducted by the above noted agencies within each State which compiled and organized the data. These agencies forwarded the data to ERS for analysis. New England is now the only U.S. region with detailed and comparable State-by-State information on the residential use of wood energy and the resulting displacement of conventional energy sources.

ACKNOWLEDGMENTS

The authors acknowledge a number of people and organizations that made significant contributions to the Maine report. Nancy Holmes, Wood Energy Specialist of the Maine Office of Energy Resources, was the primary coordinator of the survey efforts. Considerable assistance was provided by Judy Jalbert, Forestry Products and Energy Development Supervisor of Coastal Enterprises, Inc. David Brooks, the former RC&D forester of the Time and Tide RC&D area, and Dave Chase, the former RC&D coordinator, Threshhold to Maine RC&D area, were instrumental in initiating the fuelwood study in Maine. Other contributors were Hyde School, Maine Reach, Brunswick League of Women Voters, Small Woodlot Owners Association of Maine, Eastern Maine Development District, Somerset Industrial Committee, Northern Maine Regional Planning Commission, Androscoggin Valley Regional Planning Commission, and the Maine Audubon Society. The Planning and Development Division, Maine Forest Service, provided excellent reviews of drafts of this report.

Maria Lenz, an ERS economic and statistical assistant, computed many of the results presented in this report.

Appreciation is also tendered the following individuals who provided many helpful suggestions and assistance in the development of the study and in the preparation of this report: Robert McKusick, John Wenderoth, Ted Cady, Cliff Jones, Sheryl Davies, Beth Green, Charles Taylor-Brown, Roger French, Elizabeth Swain, Daniel Vining, Kay Wilhelm, Frances McDevitt, Helene Blank, Joseph Barse, William Crosswhite, Dwight Gadsby, James Sayre, Debra Ritter, Anthony Grano, John Hostetler, Jerry Jolly, Frank Holt, Donald Jones, Roy Gray, Melvin Cotner, Velmar Davis, Carolyn Harper and Robert Francis.

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HIGHLIGHTS

Most Maine residents have experienced sharp increases in home heating costs since 1974, and as a result, many installed wood-burning stoves or central wood-fired heating systems. Major findings of this study are:

* Over 30 percent of all Maine households and 51 percent of owner-occupant households used wood-burning stoves or central wood-fired heating systems during the 1979-80 winter.

* Six percent of owner-occupant households in Maine installed their first wood-heating apparatus in 1979, contributing to a 27 percent annual increase in residential fuelwood use.

* Homeowners who use airtight wood stoves burn approximately 4 cords per household during a winter and estimate that they derive 68 percent of space heat from wood.

* Residents using wood stoves are more likely to make energy conservation improvements and are more likely to lower thermostat settings than those not burning wood.

* Over 731,000 cords of wood were burned by Maine households during the 1979-80 winter.

* Purchased wood supplied 42 percent of the cordwood obtained for the 1979-80 winter. Although a majority of cords were cut by household residents for their use, 63 percent of wood-burning residents purchased some portion of their wood.

* Splitwood constituted only 35 percent of cords purchased. Ninety-four percent of cords purchased were hardwood; 81 percent were delivered.

* Residents harvested 25 percent of all the cordwood they obtained from the 4 percent of productive forestland that is owned in private woodlots of less than 20 acres.

* Wood energy supplied 24 percent of all energy demanded by Maine residents. This energy was converted into 6 trillion Btu's of residential space heat.

* By substituting wood, Maine residents are displacing $54 million in petroleum and $22 million in electricity. Residents spent approximately $24 million of these savings on the purchase of cordwood.

Wood and Energy in Maine

Mark R. Bailey
Paul R. Wheeling

INTRODUCTION

Since the 1973-74 oil embargo, Maine households, like those in the other New England States, reacted to the resulting energy crisis by substituting wood energy for fuel oil and electricity. This transition from conventional energy sources to wood energy resulted in the burning of 731,000 cords of wood by Maine households during the winter of 1979-80. Increased fuelwood consumption is resulting in larger demands upon the forest resource, displacement in fuel oil and electricity, and an increase of energy dollars spent in local economies.

This report describes how Maine families obtain cordwood, volumes of fuelwood burned, trends in fuelwood use, the economic impacts of cordwood substitution, and the relationship between fuelwood cut and the forest resource.

REASONS FOR THE TRANSITION TO WOOD

Wood was the major energy source in New England until the early 1900's. Forests covered only 20 percent of the land area by the mid-1800's, due to the use of wood as a fuel and the need for farmland. As the population grew, demand for wood for building and fuel continued to grow until the supply was outstripped by the latter half of the 1800's. Fuelwood deficits were made up by imports from the Canadian Maritime Provinces (1). (Underscored numbers in parentheses refer to items in the references.) Demand for fuelwood peaked during the late 1800's, and coal became more and more popular. Demand for fuelwood declined precipitiously after widespread adoption of petroleum-burning furnaces. Forest acreage expanded as demand for wood energy declined and the region's economy shifted to manufacturing, idling much agricultural land which reverted to forest. By 1970, forestland encompassed nearly 80 percent of land in the region.

Bailey, an ERS agricultural economist, is the New England Fuelwood Study leader. Wheeling, formerly an ERS community planner, was the deputy leader of the study.

Fuel oil prices, in constant 1972 dollars, have increased approximately 240 percent in New England since the 1973-74 oil embargo. Petroleum accounts for over 75 percent of the energy used in New England, and over 75 percent of petroleum consumed is imported from foreign sources. Petroleum accounts for 70 to 80 percent of the energy consumed in Maine and between 75 to 85 percent of conventional energy demanded by residences. Heating requirements of a Maine household are 169 percent of the national average. As a result, Maine residents have keenly felt the increasing cost of home heating, and their desire to lower heating costs has been a central factor contributing to the transition to wood heat.

TRANSITION TO CORDWOOD USE IN MAINE

Use of wood heat in Maine in 1970 was well above the national average which was less than 1 percent of homeowners (5). Still, only about 10 percent of the State's homeowners used wood-heating appliances, and much less heat was provided per wood-burning stove.1/ During the 1979-80 winter, 51 percent of Maine's homeowners used wood-fired heating equipment as either their primary or supplementary source of space heat, up 5 percent from the previous year.

Trends in Residential Wood Use

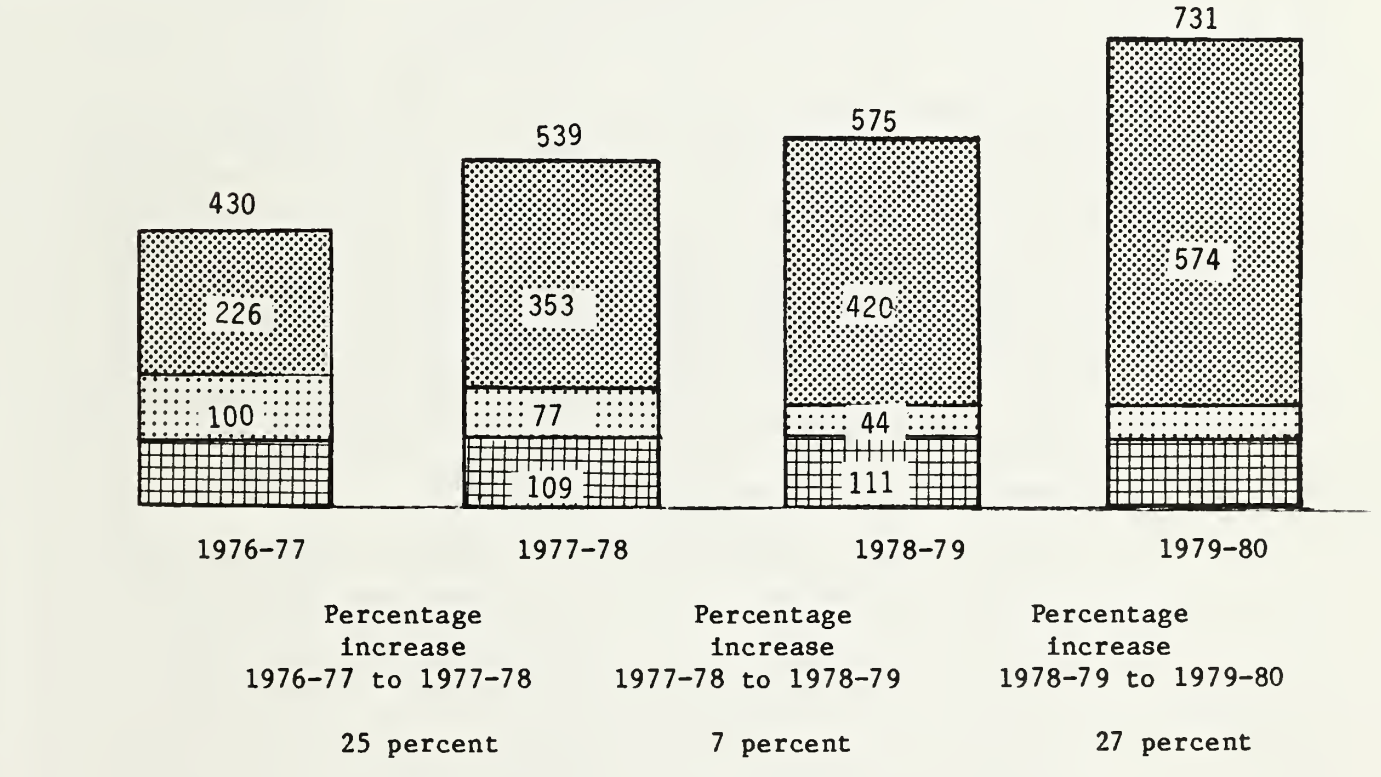
Total numbers of wood stoves and wood-burning furnaces installed in Maine in 1976, 1977, 1978, and 1979 were 15,000, 22,000, 24,000, and 54,000, respectively. These installations overstate the transition to wood heat because some replaced or upgraded previously existing wood-burning equipment.

Estimates of the volume of wood burned in residences during the winters of 1976-77 through 1978-79 were developed from the 1979 Maine fuelwood survey. Trends in residential wood use--the fuelwood volume differences between the surveyed winter and the previous winters--is based primarily upon when wood-burning equipment was installed and the type of equipment, if any, used prior to that date. The 1980 resurvey permitted a more refined estimate of the wood-burning trend since changes in dwellings and associated changes in wood-burning equipment (new equipment, replacement of similar equipment, and upgraded equipment) were considered. The annual increase has averaged 20 percent over 1976-77 to 1979-80 (fig. 1). Of the 931 owner-occupant households responding to questions in the initial survey, 39 percent used a wood stove during the winter of 1978-79. The majority of these stove users used a wood stove during the previous winter (31 percent of all owner-occupant households), while 3 percent of homeowners changed from

1/ The 1970 figure of 10 percent was derived by extrapolating data back in time.

fireplace to stove use, and 5 percent changed from not burning wood to stove use. Approximately 6 percent of homeowners used a central wood furnace during the winter of 1978-79, including 4.5 percent who previously used a wood furnace and 1.5 percent who installed one during 1978. Those installing a central wood furnace were fairly equally divided between households previously not burning wood, using a fireplace, or using a wood stove. Finally, about 4 percent of households discontinued wood use.

Figure 1--Trend in residential wood use, four winters, 1976-1980, Maine



The increase in wood use during 1979 is largely due to the net increase of 22,000 owner-occupant households using wood-burning stoves and central wood-fired heating systems (table 1). This change increased the percentage of homeowners using wood-fired heating equipment from 46 during the 1978-79 winter to 51 during the 1979-80 winter.

Net change in wood burned is calculated from the following:

1. Change in type of wood-burning apparatus used and the resulting change in average number of cords burned.

2. Change in average volume of wood burned per central wood-fired system.

3. Change in number of households.

The Maine surveys, as well as the other New England State surveys, give no indication that the increase in wood use will not continue, especially if the relative costs of conventional fuels continue to rise. Further, the surveys do not record the most recent increase in wood use which is expected in response to the 1981 petroleum price decontrol and subsequent rises in fuel oil and kerosene prices. The rational response to increasing conventional heating fuel prices indicated by the survey findings implies that an increase in wood energy use will occur if and when natural gas is decontrolled (assuming a price increase will result). As the costs of conventional energy rise relative to the cost of wood energy, more households will substitute wood energy.

Prior to the oil embargo of 1973-74, fuel oil was relatively low in price, and as a result, most residences in Maine were heated by that energy source. During the same pre-embargo period, the marginal cost of wood supplied heat was higher than fuel oil supplied heat, and thus, most cordwood was burned for aesthetic purposes rather than as a substitute for conventional energy. The increases in fuel oil prices that followed the 1973-74 petroleum embargo, however, had a profound impact upon the use of wood for energy not only in Maine but in all of New England as well.

Consumers realized that even with the increased prices of fuel oil, the non-airtight stoves that dominated the market were too inefficient to make wood energy competitive with conventional energy. As a result more efficient stoves were designed and built and the users were able to extract more energy per pound of wood burned. The increased efficiency made wood supplied heat significantly lower in price than that

Table 1--Changes in Maine residential wood use during 1979, by household groups

Household group 1/	Households 2/ in wood use groups		Household change in equip. use during 1979	Volume of wood burned		Change in volume of wood burned relative to 1978-79
	Jan. 1979	Jan. 1980		Winter 3/ 1978-79	Winter 1979-80	
	-----Number-----			-----Cords-----		Percent
Owner occupant	256,832	277,736	20,904	463,865	627,496	35
Not burning wood	113,260	114,430	1,170	--	--	--
Using only fireplace	25,368	23,001	-2,367	43,831	53,288	22
Using open wood stove	44,574	40,827	-3,747	134,089	134,938	0
Using airtight wood stove	55,226	82,803	27,577	200,246	332,232	66
Using a wood furnace	18,404	16,675	-1,729	85,699	107,038	25
Rental occupant	108,608	117,448	8,840	55,110	47,588	-15
Not burning wood	87,682	105,144	17,462	--	--	--
Burning wood	20,926	12,304	-8,658	55,110	47,588	-15
Second and seasonal homes	57,727	57,727	0	56,061	56,061	0
Not burning wood	26,240	26,240	0	--	--	--
Burning wood	31,487	31,487	0	56,061	56,061	
Total	423,167	452,911	29,744	575,036	731,145	27

Note: -- = not applicable

1/ Household classifications are stratified by tenure categories which indicate owner-occupied dwelling units, rental-occupied dwelling units, and second and seasonal dwellings, which may not be occupied throughout the year. Stratification by tenure allows use of census data to control the estimate for differential telephone answering rates.

2/ Estimates of the number of dwelling units owner-occupant and rental-occupant are derived from the preliminary report of all housing units of the 1980 census and tenure reported by the 1970 census. Members of the tenure classes are termed households for convenience.

3/ Estimates of the volume of wood burned are reduced 17 percent from volume reported by respondents to correct response bias. Major forms of response bias identified by subsurvey and resurvey are under-reporting of not-at-home households, and over-reporting of the volume burned due to imprecise knowledge of the cord measure.

4/ Insufficient data are available to estimate wood use in these households.

supplied by fuel oil. As a consequence, a very high proportion of the stoves installed since 1974 have been of the efficient airtight type (table 2). The increased wood-burning efficiency of such stoves made the marginal cost of wood less than that of fuel oil, and as a result, the average amount of wood burned in airtight stoves increased. Compared to those households that use inefficient, non-airtight stoves, those using airtight stoves typically burn 20 percent more wood per year, and derive a much greater amount of heat. Maine households are consequently experiencing greater displacements of fuel oil and electricity, as well as larger savings in heating costs.

Table 2--Proportion of various wood-burning apparatuses installed in Maine

Period installed	Open woodstove	Airtight stove	Wood furnace
		Percent	
Before 1974	46	35	19
1974-76	40	46	14
1977-79	30	55	15

Future Use of Wood for Energy

Future residential demand for wood energy is a vital matter to those concerned with forest resource management, energy planning, air quality management, forestry-related employment, and wood stove manufacturing. Reliable projections of wood energy demand are now impossible because changes in major influences on wood use, which include prices of fuel oil, electricity, and natural gas, cannot be predicted. However, relationships identified in this analysis point to at least six factors having influence on the use of wood energy: relative cost of energy, perceived problems with wood use, excess demands on the forest resource, air pollution abatement regulations, increased home insurance rates, and state liability laws.

Relative Cost of Energy

The most influential factor on future demand for wood energy is the change in relative costs of heating with alternative fuels. Three survey findings substantiate this conclusion:

1. Residential household use of wood-fired heating equipment is disproportionately concentrated in those households displacing more expensive heating fuels. For example, 70 percent of Maine homeowners using electricity as a conventional fuel use wood heat, as compared to 44 percent of those using the relatively less expensive fuel oil. A still smaller percentage of homeowners using natural gas, the least expensive source of energy, reported use of wood heat.

2. A greater percentage of New England homeowners use wood heat in areas of relatively low cordwood prices.

3. The installation rate of wood-fired heating equipment has paralleled increasing petroleum prices.

Increases in the relative price of fuel oil, electricity, or natural gas will likely spur an increase in wood use. At the same time, increases in the relative price of cordwood would decrease wood use by households purchasing wood. There is a large latent wood energy demand by industries that could convert to wood-fired boilers. Current energy policy in Maine encourages such industrial wood use. However, if such demands were realized, the relative price of wood energy could increase and approach that of conventional energy. Then, other alternative energy sources, particularly coal and solar, would become more competitive.

Perceived Problems with Cordwood Use

Growth of residential wood use has been somewhat dampened by several problems which non-wood burning households presently associate with wood use. Such homeowners most frequently identify potential hazards of burning wood as the major reason why they do not use wood (table 3). Renters identify problems concerned with getting permission from the landlord, cost of the stove, and locating adequate cordwood supplies.

Excess Demand on the Forest Resource

Residential long-term fuelwood demand on the forest resource in Maine is but a small fraction of the State's renewable resource base. Although there are New England areas utilizing wood at levels above sustainable yield, shortages have not occurred in those areas because of large standing stocks and importation of cordwood.

All current demand (residential and industrial energy, cordwood exports, pulp, timber products, recreation, and wildlife) is being met. There are concerns, however that as

the demand for wood energy increases, cordwood and stumpage prices may increase, new technologies such as whole tree chipping may have major impacts on the forest resource, and the potential for overcutting may rise.

Table 3--Perceived problems with wood use by owner-occupant households not burning wood, 1979, New England

Perceived problem	Maine	New Hampshire	Vermont	Massachusetts	Connecticut	Rhode Island
			Percent 1/			
Time and effort in cutting wood	24	19	10	20	45	6
Price of fuelwood	32	23	8	15	53	4
Locating adequate supplies to purchase or cut	21	13	4	9	35	3
Potential hazards of burning wood	38	56	66	49	34	47
Cost of stove	37	13	4	13	27	5
Inconvenience in handling	11	26	29	20	0	21
			Number			
Sample base	229	247	186	779	83	150

1/ Percentages do not add to 100 since more than one reason was often given by each respondent.

Potential Pollution Regulations

Increased wood burning has raised pollution levels to the point that some areas now control the use of wood energy (Portland, Oregon and Vail, Colorado). Topographical characteristics of Maine, as well as the other States in New England, together with increased burning of wood, have also resulted in locally increased ambient pollution levels. As use of cordwood continues to increase, degradation of air quality may result in environmental controls and public awareness that could limit increases in household use of wood for energy.

Home Insurance Policy Premiums

More house fires have occurred with the increasing use of fuelwood. While the majority of house fires related to wood burning result from improper installation of wood-burning equipment, a number of such fires are a result of chimney fires. The chimney fire problem is further exacerbated by the increasing number of airtight stoves. Maximum stove efficiency is a function of adequate oxygen, fuel, and burning temperature. Too much air results in excess heat going up the chimney; too little air results in a cooler fire, a cooler flue, and an increase in creosote (condensed gases) production. Many households operate airtight stoves with too little air which, while extending the period between reloadings, also increases creosote formation. Creosote buildup increases the potential of chimney fires and related house fires. This problem can be minimized by cleaning the chimneys and letting the stove burn hot for specified periods on a regular basis as recommended by manufacturers.

A number of insurance companies will not issue household insurance premiums to mobile homes using wood stoves. Many insurance companies are comtemplating a supplementary premium for houses that use wood stoves if the incidence of house fires resulting from the operation of wood-burning apparatuses increases much further. Such premiums could dampen the demand for new wood-burning equipment and consequently for fuelwood as well.

State Liability Laws

State liability laws may constrain wood cutting. Prior to the resurgence of cordwood use, owners of forestland may have been liable for injuries received by individuals cutting wood on their land. As a result, many landowners did not permit individuals to cut wood on their property, and thus accessibility to fuelwood sources was limited. Some New England States have countered this legal constraint by implementing legislation limiting homeowner liability if cordwood stumpage is given away.

WOOD CONSUMPTION AND ENERGY CONSERVATION BY MAINE HOUSEHOLDS

Maine families have responded to increasing heating costs and uncertain energy supplies by adopting fuelwood heating, making heat conservation improvements, and changing thermostat operations (lowered settings, zoned heating, and time heating).

Residential Use of Wood for Energy

Maine families burned 731,000 cords of fuelwood during the 1979-80 winter (table 4). Over 30 percent of all households and 51 percent of homeowners used a wood-burning stove or central wood-fired heating system. Thirty percent of the homeowners interviewed reported wood as the fuel which "provides the most heat" for their residence. The increase in residential wood use recently has varied between 7 and 27

percent per year, reflecting initial installations of wood-heating equipment and some upgradings of existing equipment. The substitution of wood energy has resulted in a more healthy State economy because dollars that would have been spent on imported oil remain in the State to be spent on local goods and services, including locally produced fuelwood. More information on the economic impacts of wood energy substitution appears in a forthcoming report.2/

Table 4--Volume of cordwood burned in Maine households, by county

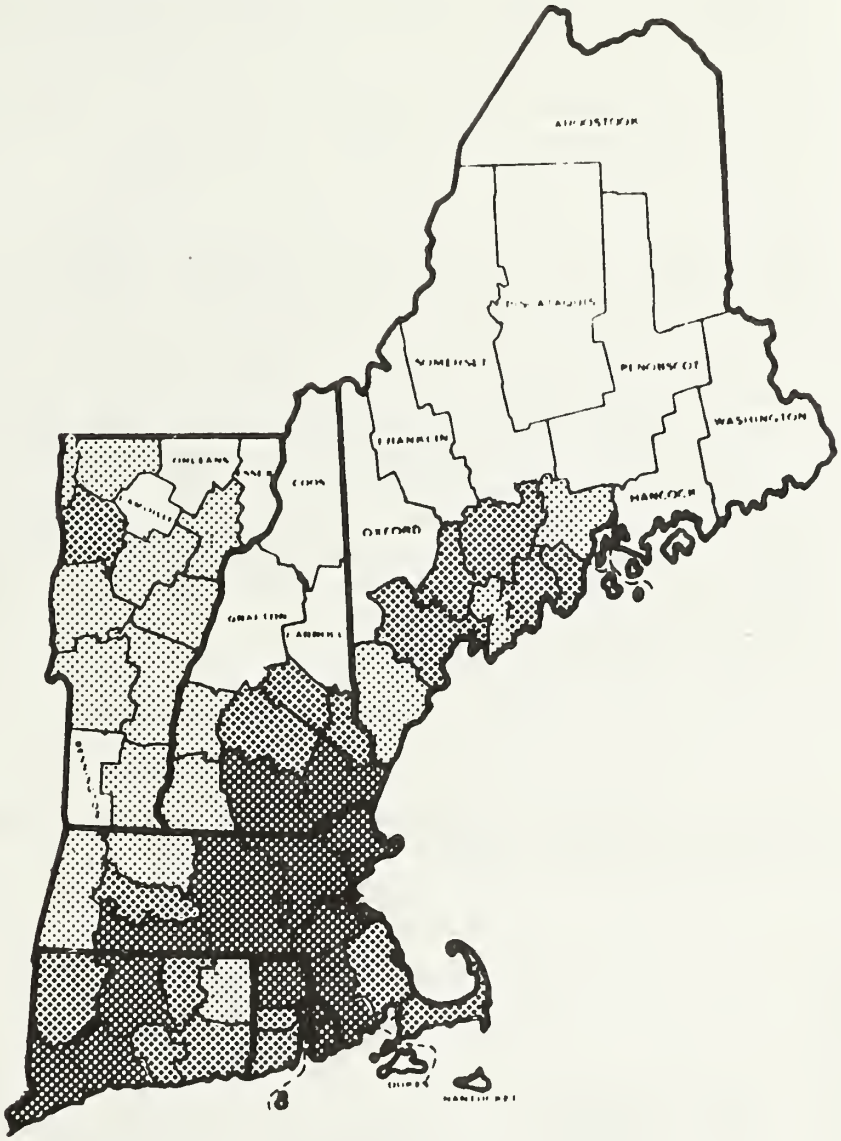
County	Volume burned 1978-79	Volume burned 1979-80	Percentage of State total 1979-80
	----Cords----		Percent
Cumberland	82,239	104,565	14
Penobscot	60,257	76,615	10
Kennebec	56,176	71,427	10
Aroostook	50,557	64,282	9
York	49,012	62,317	9
Androscoggin	38,867	49,418	7
Somerset	34,673	44,085	6
Oxford	30,528	38,815	5
Hancock	28,765	36,574	5
Washington	24,364	30,851	4
Franklin	23,726	30,167	4
Lincoln	23,700	30,134	4
Waldo	23,484	29,859	4
Knox	20,605	26,199	4
Piscataquis	18,396	23,390	3
Sagadahoc	9,686	12,315	2
Total	575,036	731,145	100

Patterns of Cordwood Use

The primary stress on fuelwood resources is not due to rural wood stove use. Intensity of fuelwood use per unit of land area is largely determined by population; thus, areas with more households generally burn a larger total volume (table 4 and fig. 2).

2/ Mark R. Bailey and Paul R. Wheeling. "Wood and Energy in New England: A Regional Perspective," New England Fuelwood Study. Econ. Res. Serv., U.S. Dept. Agr. Forthcoming.

Figure 2--Intensity of residential demand for fuelwood, 1978-79, New England



Impact of Wood-Burning Equipment

There are a variety of wood-burning appliances, ranging from traditional open wood stoves to relatively sophisticated airtight stoves and central wood-fired heating systems. In 1979, 17,000 Maine homeowners used central wood-burning furnaces, 83,000 used airtight wood stoves, and 41,000 used open wood stoves. Almost half the wood consumed by households in Maine was burned in airtight wood stoves.

The average number of cords a household is likely to burn, and the number of Btu's that may be expected, depends on the type of apparatus used (fig. 3). Households using airtight wood stoves burned an average of 4.4 cords of wood during the 1979-80 heating season. The actual volume burned by a household over a winter varies greatly, ranging from roughly 3 to more than 6 cords per year. Airtight wood stoves in Maine provide an average of 44 million Btu's of available space heat per household during a winter, assuming a 50 percent operating efficiency. Such a stove could provide almost half the heating requirements of a home requiring 90 to 100 million Btu's of space heat per year. Maine homeowners, however, estimate that their airtight wood stoves provide 68 percent of space-heating needs (table 5).

Figure 3--Average volume of cordwood burned and available heat per household, by type of apparatus used, winter, 1979-80, Maine

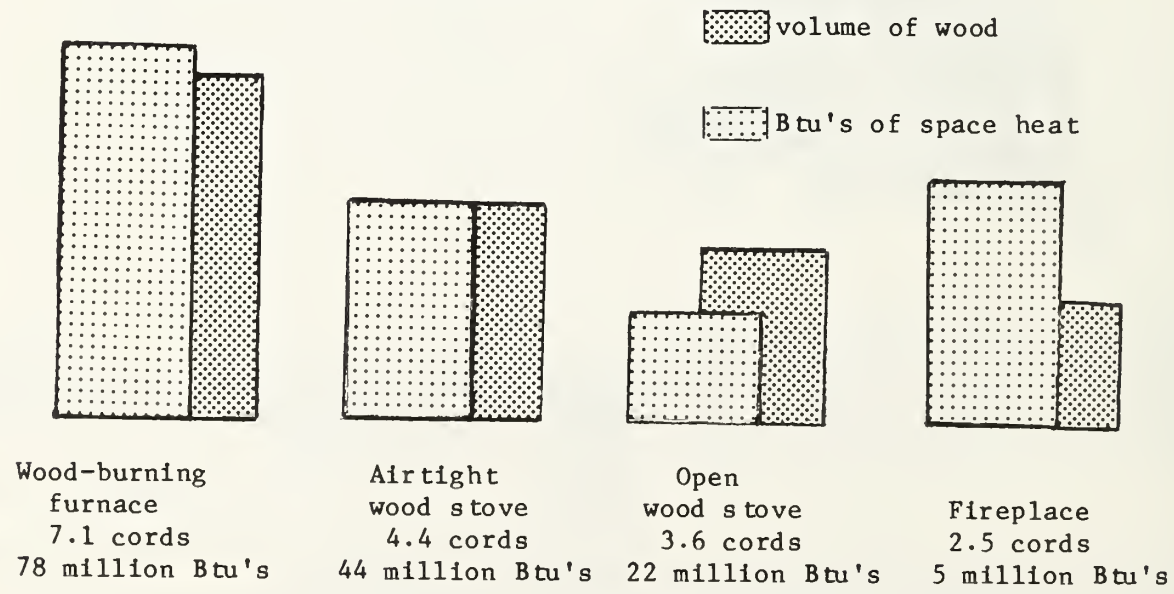


Table 5--Wood-burning characteristics averaged for owner-occupant households, by apparatus type, winter, 1978-79, Maine

Apparatus	Wood burned	Available heat 1/	Estimated savings in conventional fuel 2/	Homeowner estimate of percentage of heat from wood 3/	Average daytime thermostat settings 4/	Efficiency assumed for study
	Cords	Btu x 10^6	Dollars	Percent	Degrees	Percent
Open fireplace	1.7	2	90	11-23	66	5
Efficient fireplace	2.5	8	N/A	29-34	67	15
Traditional wood stove	3.3	20	267	33-49	64	30
Airtight wood stove	3.9	39	314	45-68	63	50
Wood furnace (combinations incl)	5.1	56	497	60-73	64	55

1/ Available heat calculated from an estimated 20 million Btu per cord times average number cords burned times assumed efficiency of wood-burning apparatus.

2/ Based largely upon fuel oil costing 55 cents per gallon. Savings are an average of homeowner estimates.

3/ Values on left side calculated from estimates of dollar savings and cost of conventional fuel; values on right side estimated as a percentage by respondent.

4/ Estimated thermostat settings determined by the New Hampshire fuelwood survey based upon data provided by the New Hampshire Governor's Council on Energy for similar household groups in New Hampshire.

The New England survey respondent estimates of the proportion of space heat provided by wood were significantly higher than estimates derived by calculating the amount of conventional energy displaced by the volume of wood burned. Owner-occupant residents using both an airtight stove and an oil-fired central furnace consistently reported conventional fuel cost reductions that reflect a greater than one-for-one value of wood heat substitution. This difference may be explained by a lack of information on the amount of useful energy which a household derives from a cord of wood. Also, residents installing and operating wood-burning equipment may use less energy than they previously used, and wood-burning equipment may provide a quality of heat that results in less demand for fuel.

During the 1978-79 winter, households using airtight stoves reported supplying 45 to 68 percent of space heat needs from wood (table 5). The lower estimate is a minimum calculated by conservatively estimating the energy in wood burned and equipment burning efficiency. The upper limit is derived from the respondents' estimates of the percentage of heat supplied by wood.

The wood-burning apparatus heavily influences the magnitude of fuelwood consumption and conventional fuel savings. The airtight wood stove, which has recently dominated installations, shows a consistent pattern of wood consumption per household across most New England States and from year-to-year in Maine. Once installed, characteristics of the wood stove and its placement largely determine the volume of wood burned and conventional energy displaced. A subsequent increase in the cost of the conventional fuel does not generally result in a significant change in the volume of wood burned in wood stoves already installed. Of course, the volume of wood burned by a household is influenced by access to fuelwood, cost of the fuel displaced by wood at the time of the installation, housing type, and the extent to which the home is insulated. Newly developed apparatuses which increase woodburning efficiency (e.g., the forced air stick furnace and designs incorporating catalytic converters) may change fuelwood demand.

Cost Relationships of Conventional and Wood Energy

The 1980 Maine survey recorded both primary and secondary heating fuels in order to identify the relative cost relationships between heat supplied by wood and by the conventional fuel available to the household. Information on relative costs served as a base in analyzing the household decision to use wood heat. The price differential between purchased wood and fuel oil in Maine resulted in heat provided by fuel oil

costing 95 percent of that provided by wood in 1978 and costing 180 percent of heat provided by wood in 1981 (table 6). Households using more expensive energy sources have a greater tendency to install wood-burning equipment than households using less expensive energy sources. Forty-four percent of homeowners using fuel oil and 70 percent of homeowners using electricity for heating have installed wood-fired heating equipment. Only 30 percent of homeowners who use natural gas, the least expensive energy source, have installed a wood stove or central wood-fired heating system.

These patterns of relative cost and tendency to install wood-burning equipment indicate that household decision resulting in the use of wood heat are primarily a rational attempt to lower heating costs.

Use of Energy Conservation Measures

Maine households also reduce heating costs through home improvements and thermostat operations directed at energy conservation. Improvements in existing homes may include upgrading insulation, installing storm doors and windows, caulking, and weather stripping. Changes in thermostat operations, which include lower thermostat settings and heating less than the entire home, decrease a households' heating demand. While a wood stove may provide normal or higher than normal temperatures in a central or often used room, peripheral areas of the home may cool to the thermostat setting or lower. Lower temperatures during periods when the wood stove is not attended also may result in energy cost reductions.

Respondents addressed five specific types of energy conservation improvements. Most homeowners indicated that they had made one or more of these home improvements during the past 3 years. Although few had installed solar water heat, performed furnace maintenance, or improved caulking and weather stripping, many had installed storm windows and a majority had made insulation improvements (table 7). At least 16 percent of Maine homeowners improved their insulation each year. Homeowners using an airtight wood stove were approximately 20 percent more likely to improve insulation than households not burning wood or using an open fireplace.

Lowered thermostat settings are more likely to be found in those homes using wood heat. Questions concerning thermostat settings were included in the resurvey of household wood use in New Hampshire, where wood use is similar to Maine's. New Hampshire households using an airtight wood stove reported an average daytime thermostat setting of 63 degrees and a nighttime setting of 60 degrees, several degrees lower than those not burning wood or using only a fireplace. These lower settings save an additional 10 to 15 percent of space heat costs.

Table 6--Relative cost of alternative heating fuels, 1978 to 1981, Maine

Energy source and burner	Applicable unit	Cost/unit		Energy per unit	Typical burner efficiency factor	Available energy	Cost per million Btu's		Relative Cost per Btu 1/	
		1978	1981				1978	1981	1978	1981
		Dollars		Million Btu's	Percent	Million Btu's	Dollars		Percent	
Wood, airtight stove	cord	59	77.50	2/ 20.0	50	10.0	5.90	7.75	100	100
Central system	cord	59	77.50	2/ 20.0	55	11.0	5.36	7.05	91	91
Electricity, Resistance	kWh	3/.0402	4/.0736	0.0034	100	.0034	11.78	21.57	200	278
Natural gas Furnace	1000 cu.ft.	3/.00357	5/ N/A	1.00	70	.700	5.10	N/A	86	N/A
LP gas (propane), Furnace	gallon	3/.349	5/1.26	.096	70	.067	5.22	18.85	88	243
#2 fuel oil, Furnace	gallon	3/.504	5/1.26	.139	65	.0902	5.59	13.98	95	180

Note: N/A = not available.

1/ Computed by dividing the energy price by the price of wood energy in from an airtight stove.
2/ Btu/cord of wood weighted according to volumes of hard and softwood consumed in a typical residential cord.
3/ Price data from State Energy Fuel Prices by Major Economic Sector from 1960-1977 (some for 1978): Preliminary Report and Documentation, U.S. Dep. Energy, July 1979.
4/ Average price/kWh, 1980.
5/ Price estimates from Maine Energy Office, Sep. 1981.

Table 7--Owner-occupant household energy conservation improvements, by apparatus, winters, 1976-79, Maine

Apparatus	Making insulation improvement	Installing storm windows	Caulking or weather stripping	Sample size
	--------Percent----------			Number
Owner-occupant household not burning wood	43	28	23	401
Owner-occupant household using an open fireplace	45	39	38	66
Owner-occupant household using an efficient fireplace	63	58	42	24
Owner-occupant household using a traditional wood stove	55	41	31	166
Owner-occupant household using an airtight wood stove	51	35	35	214
Owner-occupant household using a central wood furnace	65	47	34	62
All homeowners	49	35	30	933

Energy conservation improvements, lowered thermostat settings, and the substitution of wood for a more expensive heating fuel are measures which tend to occur, in combination, in certain households. This suggests that these measures are part of an overall household strategy directed at the reduction of heating costs. Households not burning wood are consistently less likely to make an energy conservation improvement (table 7).

OBTAINING CORDWOOD IN MAINE

Maine households obtain cordwood through purchase and/or household harvesting of such wood. While wood-burning residents cut more wood than they purchased, more than 59 percent of them purchased at least some part of their cordwood. Thirty-five percent of the cordwood marketed in Maine was sold as splitwood. Market demand for cordwood is directly related to density of population, or more specifically, to density of owner-occupant households.

Seller services such as bucking, splitting, delivering, and stacking all influence cordwood price. Market demand for purchased cordwood will likely increase due to an increase in the number of households using wood-fired heating equipment and possibly due to an eventual increase in the percentage of cordwood purchased.

The bulk of cordwood harvested by residents is cut on family-owned lots attached to their residence. As a result, such harvesting is concentrated on a small portion of forestland. Harvesting by residents does not seem to be directed at improving the quality of woodlots since only a very small proportion of such operations received guidance from professional foresters. Most of the wood that residents cut was not suitable for producing lumber since the vast majority of the wood cut was dead, blown down, rotten, or residue from land clearing operations.

Volume of Cordwood Purchased and Cut by households

Maine residents purchased nearly 369,000 cords and cut over 505,000 cords for their own use during 1979 (table 8). For the previous winter, they purchased 342,000 cords and cut 299,000 (table 9). During 1979, owner-occupants using a wood-burning stove or central wood-fired heating system acquired 86 percent of all wood obtained by residences even though they constituted only 36 percent of all households. Homeowners using airtight wood stoves purchased 169,000 cords during 1979, constituting the largest market group. Although wood burners using only fireplaces purchase a higher percentage of their wood than those using wood stoves, the total volume of purchased fireplace wood is a relatively insignificant portion of marketed fuelwood.

Considerable county-to-county differences are evident in the market demand for cordwood. The volume of wood purchased by residents in a county parallels the volume of wood burned and county population (tables 10 and 4).

Table 8--Cordwood obtained for the winter of 1979-80, by household group, Maine

Household group	Volume cut	Volume purchased	Portion purchased	Total Volume acquired
	----Cords----		Percent	Number
Owner occupant	482,869	266,623	36	749,492
Using only fireplace	48,666	9,294	16	57,960
Using open wood stove	89,822	67,692	43	157,514
Using airtight wood stove	214,121	169,147	44	383,268
Using a wood furnace	103,260	30,490	23	133,750
Rental occupant	16,933	47,678	74	64,611
Second and seasonal homes	5,215	54,651	91	59,866
Total	505,017	368,952	42	873,969

The Maine surveys separately recorded the volume of wood burned, purchased, and harvested by the respondent's household. Maine residents obtained 20 percent more wood during 1979 than was burned during the 1979-80 winter. In the previous year, 11 percent more was obtained. This difference may be the result of initial installations of wood stoves. Families who install wood-fired heating equipment have a tendency to build up a large inventory to carry over into following winters. This is especially true for families who purchase green wood for seasoning. The wood remaining after the burning season also results from warmer than normal winters and as a hedge against uncertainty in conventional energy supplies. The volume of wood obtained by residences was greater than the volume burned in all New England states.

Table 9--Cordwood obtained for the winter of 1978-79, by household group, Maine

Household groups	Volume Cut by households	Volume Purchased	Total acquired	Portion purchased	Average volume purchased
	-------Cords 1/-------			Percent	Cords
Owner occupants using fireplaces	23,400	28,600	52,000	55	2.5
Owner occupants using wood stove or furnace	241,800	234,300	476,100	49	3.7
Other households	33,300	79,100	112,400	70	2.4
Total	298,500	342,000	640,500	53	3.6

1/ rounded to nearest 100.

Purchased wood accounted for 53 and 42 percent of the wood obtained by households during 1978 and 1979, respectively (tables 8 and 9). The 11 percent difference between the two winters suggests that households are beginning to rely more on purchased cordwood. Thus, households installing stoves since 1973 have greater tendency to purchase their wood (table 11).

Table 10--Cordwood obtained by households, by county, winter, 1978-79, Maine

County	Method of acquisition: Self-cut	Purchased	Total acquired	Portion purchased 1/
	Cords 2/			Percent
Androscoggin	18,800	20,400	39,200	52
Aroostook	21,800	40,700	62,500	65
Cumberland	46,100	51,300	97,400	53
Franklin	13,200	12,100	25,300	48
Hancock	5,900	23,200	29,100	79
Kennebec	32,600	23,200	55,800	42
Knox	10,800	12,600	23,400	54
Lincoln	15,500	13,900	29,400	47
Oxford	10,000	18,600	28,600	65
Pendoscot	44,300	27,000	71,300	38
Piscataquis	10,500	12,300	22,800	54
Sagadahoc	6,000	5,500	11,500	48
Somerset	15,900	23,000	38,900	59
Waldo	14,000	10,800	24,800	44
Washington	5,300	18,700	24,000	78
York	27,800	28,700	56,500	51
Total	298,500	342,000	640,500	53

1/ Percentages calculated from nonrounded data.
2/ Rounded to nearest 100 cords.

Table 11--Method of obtaining cordwood, by installation date, Maine

Period of wood stove installation	All wood cut by household	Wood cut and purchased	All wood purchased
	Percent		
Before 1974	48	21	30
1974-76	47	13	40
1977-79	41	21	38

Although only 42 percent of wood burned was purchased for the 1979-80 winter, 63 percent of households burning wood purchased some portion of their wood. The 369,000 cords of wood purchased in Maine in 1979 were bought by 176,000 households. During 1978, 40 percent of homeowners cut all of their wood, 36 percent purchased all of their wood, and 20 percent both purchased and cut. An additional 4 percent acquired no wood during 1979. This final group may represent families who burn wood stored during previous years.

In most New England States, the method by which a household obtains wood relates to its volume burned. Residents using a particular apparatus typically burn less if all their wood is purchased rather than harvested. Maine survey results do not present a definite pattern (table 12). The unusually high use of purchased unprocessed wood by Maine residents may explain these results.

Table 12--Average volume of cordwood burned by apparatus and method of acquisition, winter, 1978-79, Maine

Wood-burning group	All wood cut by households	Wood cut and purchased	All wood purchased
	----------Cords----------		
Owner-occupant using a fireplace	1.4	2.5	1.7
Owner-occupant using a traditional wood stove	3.6	3.6	3.0
Owner-occupant using an airtight wood stove	4.1	3.9	4.0
Owner-occupant using a central wood furnace	5.0	5.0	5.0

Characteristics of Purchased Cordwood

Purchased firewood comes in many forms: roundwood and splitwood of varying lengths and slab and other forms of manufacturing waste. 3/ There are also a number of services (splitting, delivering, stacking) that may or may not accompany the purchase. Splitwood accounted for 35 percent of purchased wood in 1978 and 19 percent of all wood acquired. Roundwood accounted for 61 percent, while slabwood and manufacturing waste was 4 percent of purchased firewood (table 13).

Table 13--Volume of fuelwood purchased, by form and length, 1978, Maine

Category	Cords purchased	Proportion of purchased wood in category	Proportion of all acquired fuelwood in category
	Cords 1/	-------Percent-------	
Roundwood	208,600	61	32
Greater than 4 ft.	30,800	9	4
4 ft.	140,200	41	22
Less than 4 ft.	37,600	11	6
Splitwood	119,700	35	19
Greater than 4 ft.	3,400	1	1
4 ft.	44,500	13	7
Less than 4 ft.	71,800	21	11
Manufacturing waste and slab	13,700	4	2
Total	342,000	100	53

1/ Rounded to nearest 100 cords.

3/ Roundwood refers to cordwood not processed by splitting lengthwise. In other reports, notably USDA Forest Service resource reports, roundwood refers to timber used in its original form as distinguished from industrial byproducts. Thus, the USDA Forest Service would use the term unsplit roundwood to describe this wood.

Household cordwood purchases in Maine and New Hampshire contain a higher than average percentage of unsplit wood in lengths of 4 feet or longer (table 14). Residents in these States also purchase a greater percentage of their wood. These characteristics may be the result of a more viable logging or pulping industry which can offer households home delivery of wood which can be processed by the purchaser.

Cordwood price varies according to the number and kind of services provided. Major seller services are bucking, splitting, seasoning, delivering, and stacking. Price also varies with the size of the sale, time of year, price of conventional space heating fuel, and distance from major fuelwood harvesting operations. For example, one would expect to pay a significantly higher price for a cord of split hardwood, cut to 18-inch lengths, delivered and stacked in Boston in January than for a cord of 8-foot long roundwood delivered to a central Vermont household in July.

Table 14--Characteristics of household fuelwood purchases, 1978, New England

State	Purchases split	Purchases hardwood	Purchases delivered	Purchases seasoned	Purchases made early
			Percent		
Maine	35	94	81	61	64
New Hampshire	47	92	90	64	72
Vermont	58	95	93	67	62
Massachusetts	56	92	82	82	49
Rhode Island	83	87	81	75	34
Connecticut	59	85	79	81	35

During 1978 and through the winter of 1978-79, a cord of wood cut to stove length, split, and delivered cost an average of $59 in Maine. Split cordwood prices varied somewhat across the State: $46 in Aroostook county, $55 in Kennebec county, $58 in York county and $62 in Cumberland county. (fig. 4). The median price was was $60 for the 39 New England counties reporting sufficient samples of split cordwood prices for 1978.

A more recent indication of cordwood prices is provided by a 1980-81 review of newspaper classified advertisements across New England. The price of a cord of seasoned hardwood -- cut to stove length, split, and delivered locally -- depended upon location and ranged from $70 to $125 a cord. The prices in Maine ranged from $78 in Presque Isle to $93 in Portland. 4/

Characteristics of Cordwood Harvested by Households

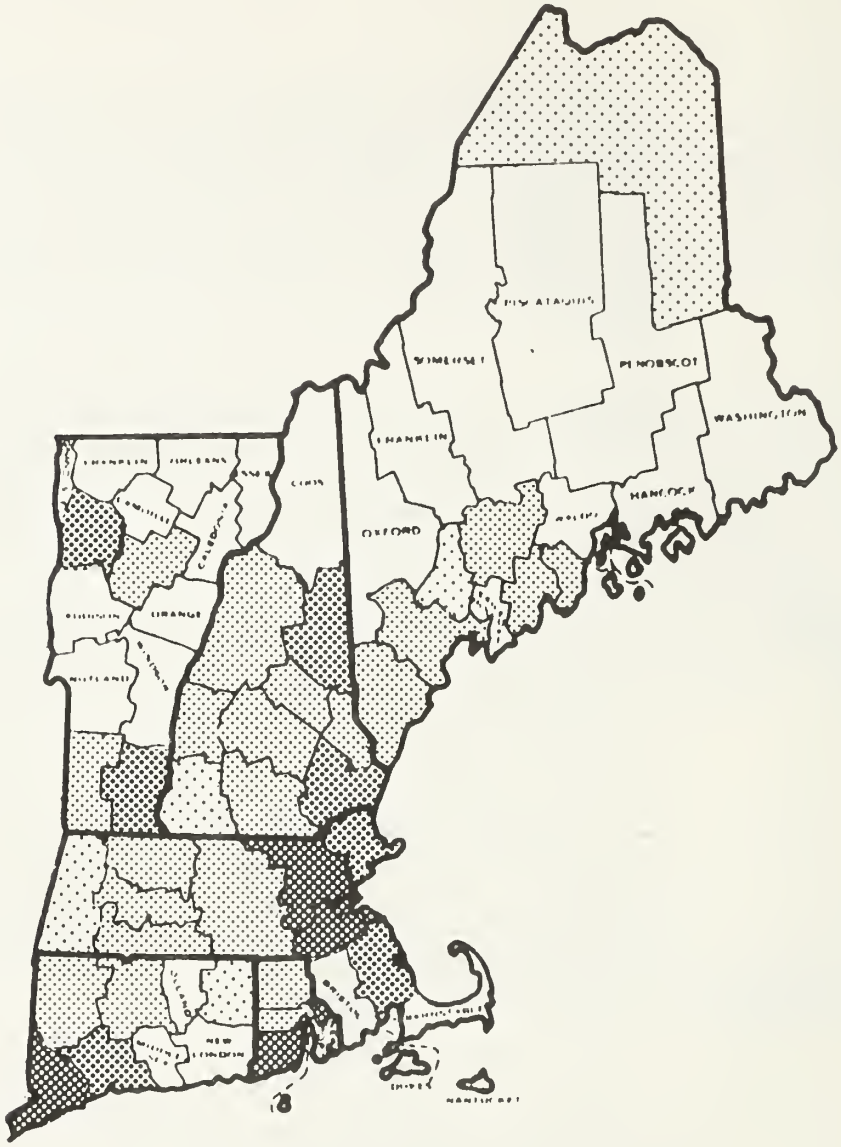
Maine families harvested 505,000 cords of wood for their own use in preparation for the winter of 1979-80 (table 8). This volume represents 58 percent of the wood burned by residences. The percentage of wood cut rather than purchased increased 11 percentage points over the percentage cut in the previous year. This sharp increase in wood harvested by residences is not expected to continue as a trend both because the pattern was reversed in most New England states and because there are some indications that some wood using residents purchase a greater percentage of their wood after several years of experience with a stove. In all, 116,000 households or 65 percent of those burning wood during the winter of 1979-80 cut some or all of their cordwood.

During 1978, 71 percent of wood harvested by Maine residents was cut from family-owned land and 11 percent was cut from a neighbor's land. In terms of land use, 78 percent of wood harvested by households was cut from privately owned, basically residential woodlots, and 53 percent was obtained from privately owned woodlots of 25 acres or less (table 15).

Harvesting of wood by households is concentrated on certain types of land. A 1972 Maine forest survey estimated that there are 16,894,000 acres of commercial forestland in Maine, with 6,797,000 acres or 40 percent privately owned by

4/ Information provided by the Northeast Solar Energy Center, Boston, Massachusetts, 1981.

Figure 4--Processed cordwood prices by county, 1978, New England
(Estimated from a 39-county sample of split cordwood prices)



$75 to $110 per cord
(area of highest cordwood price)

$62 to $74 per cord

$50 to $61 per cord

$49 or less per cord

Prices not available
(Generally high standard error
due to insufficient sample)

individuals (table 15, col. 5). 5/ The size distribution for lots of privately owned commercial forestland has been approximately projected on the basis of Conservation Needs Inventory data for Maine. Private forestland owners holding lots smaller than 50 acres own an approximate 10 percent of such forestland. Considering both of these factors, individuals privately own, in lots smaller than 50 acres, approximately 4 percent of the land in Maine that is producing or capable of producing a reasonable crop of wood.

Table 15--Source of cordwood harvested by residents for their own use, by land use, 1978, Maine

Category of land use	Volume of cordwood harvested	Portion of all household-cut wood	Average volume cut per household	Portion of all wood acquired	Portion of commercial forestland in category 1/
	Cords	Percent	Cords	----Percent---	
Small private (smaller than 25 acres)	158,000	53	3.2	25	2/ 4
Large private (25 acres or larger)	75,000	25	3.9	12	2/ 38
Farm woodlot	42,000	14	4.6	6	3/ 7
Public land	--	--	--	--	2
Forest industry	12,000	4	3.3	2	49
Other land use	12,000	4	4.2	2	0
Total	299,000	100	3.6	47	100

Note:-- = negligible amount.

1/ See (2).

2/ Distribution of commercial forestland ownings by woodlot size estimated from unpublished information soon available as: Birch, T. W., D.G. Lewis, and H.F. Kaiser. Private Forestland Owners of the United States, Resource Bull., Forest Serv., U.S. Dept. Agr., 1981.

3/ This category of commercial forestland includes all farmer-owned commercial forestland. Such forestland is not necessarily located on farms.

5/ Commercial forestland is defined by the U.S. Forest Service as forestland producing or capable of producing a certain level of crops of industrial wood and not withdrawn from timber utilization. The definition excludes narrow strips of trees, trees in heavily settled areas, and trees in inaccessible areas.

The Maine fuelwood survey results show that 25 percent of the wood obtained by households in Maine (table 15, col. 4) is harvested from less than 4 percent of commercial forestland which is in small, individually owned woodlots (table 15, col. 5). Maine families harvest a greater than average percentage of wood from farm woodlots and small, privately owned woodlots than do families in the other New England States.

Survey information from across New England on the volume, land ownership, and land use of household wood harvesting indicates the importance of the small woodlot attached to the residence. Cross-referencing the relationships of land use and land ownership in Maine shows that 42 percent of the wood cut by families and 20 percent of all the fuelwood obtained for residences (125,000 of 641,000 cords in 1978) were from woodlots smaller than 25 acres, that were owned by the harvesting family rather than by other private parties, the public, the forest industry, or a farming household (table 16). However, the small, family-owned woodlot supplies an average portion of residential cordwood in Maine when compared with all New England States (table 17).

Table 16--Source of cordwood harvested by residents, by land use, 1978-79, New England

Land use	Maine	New Hampshire	Vermont	Massachusetts	Rhode Island	Connecticut
			Percent			
Small private (smaller than 25 acres)	53	49	33	48	74	64
Large private (25 acres or larger)	25	28	34	27	26	18
Farm woodlot	14	8	23	9	--	5
Public land	--	--	5	7	--	5
Forest industry land	4	6	3	3	--	--
Other	4	8	2	6	--	8
Total 1/	100	100	100	100	100	100

Note: -- = negligible amount.
1/ May not add to 100 because of rounding.

Table 17--Cordwood harvested by residents on small, family-owned woodlots, 1978, New England

State	Volume of wood cut on family-owned, private woodlots of less than 25 acres	Portion of wood harvested by households on family-owned, private woodlots of less than 25 acres	Portion of total cordwood burned
	Cords 1/	Percent	
Maine	125,400	42	22
New Hampshire	114,000	48	29
Vermont	53,700	25	16
Massachusetts	175,900	31	21
Rhode Island	33,700	49	31
Connecticut	345,600	58	51
Total	848,300	44	29

1/ Rounded to nearest 100 cords.

Residents using a small woodlot for their cordwood supply cut and burn less wood than those utilizing larger woodlots. The average volume of wood which Maine households harvested from private, largely residential woodlots smaller than 25 acres was 3.2 cords whereas harvesting on larger private woodlots averaged about 3.9 cords. This pattern is consistent throughout New England.

In order to indicate the impact of household cordwood harvesting on the forest resource, the 1979 survey recorded the extent to which respondents utilized professional forestry assistance in marking for harvest. In Maine, only 19 percent of wood cut by households was marked by a forester (table 18).

Table 18--Use of professional foresters to mark wood cut by residents for their own use, 1978, Maine

Land Use Category	Volume of wood cut by residents	Portion of wood marked by forester
	Cords	Percent
Small private	158,000	11
Large private	75,000	22
Farm woodlot	42,000	33
Public land	--	0
Forest industry land	12,000	46
Other	12,000	0
Total	299,000	19

Note:-- = negligible amount.

Results of the surveys conducted throughout New England caused concern for the potential impact of increasing residential wood use on the forest resource. To provide more information on this resource use, the Vermont followup survey collected information that would better relate residential fuelwood demand to available information on the resource base. Because there are similar characteristics of wood use and acquisition in Vermont and Maine, the findings of the Vermont followup survey are important for Maine. Response indicates that 82 percent of the volume of cordwood harvested by households in Vermont came from the larger woodlots which are included in the Forest Service definition of commercial forestland. Other cordwood was harvested from fence rows (9 percent), yards (6 percent), and woodlots smaller than 5 acres (3 percent). Further, a large percentage of the Vermont cordwood was harvested from categories of wood not suitable for production of lumber. These include trees or branches blown down, dead, or rotten (33 percent); trees cut for land clearing (23 percent); wood left over from lumber of pulp wood harvesting (7 percent); and small trees measuring less than 5 inches at chest height (5 percent). In sum, 68 percent of the volume of wood harvested by Vermont residents for their use is cut from trees and portions of trees not suitable for producing lumber. Only five of that 68 percent represented small trees possibly appropriate for future lumber production.

Cross-referencing this information from Vermont on the quality of harvested trees and the size distribution of woodlots provides information on the conflicts between cordwood and other wood products. For the 82 percent of wood which households harvested from commercial forestland, only 36 percent came from trees or portions of trees that could have produced lumber. Assuming that about half of the volume of each of these trees is suitable for lumber feedstock, it is possible to estimate that 15 percent of cordwood harvested by Vermont residents for their own use could have been used for lumber production. The families of Vermont harvest an unusually large percentage of their wood from farm woodlots and large, privately owned woodlots, suggesting that the percentage of household harvested cordwood that could have been used for lumber production in Maine may be below 15 percent.

Household harvesting of cordwood may not, at present, improve forest productivity. Cordwood cut from trees or branches blown down, dead, or rotten constitutes 33 percent of the wood harvested by families, and trees cut for land clearing provide 23 percent of wood harvested by families in Vermont. The dominance of these two categories and the low percentage of cordwood marked by a forester for household harvesting in Maine indicate that wood cutting by households may not be directed towards improving quality and productivity of woodlots. These relationships also suggest that most household woodlots have not yet been harvested to the extent that cuttings reduce growing stock on permanent forestland.

ECONOMIC AND RELATED RESOURCE ISSUES

The transition to wood energy has produced major changes in forest resource use, conventional fuel imports, household income, local employment, and household safety. This section summarizes these survey findings within the context of available State-level data on these issues.

Economic Impact of Residential Wood Energy 6/

Maine residents displaced $54 million of petroleum and $22 million of electricity during 1980 through the substitution of wood energy for conventional heat sources (based upon home heating oil priced at $1.00 per gallon and electricity at $59 per 1,000 kWh in 1980 prices.

6/ A more detailed analysis involving the use of an input/output model will appear in a forthcoming report (see footnote 2).

The path of these savings through the local economy resulted in multiplied economic benefits, increasing local employment and household income.

Dollars not spent by households on imported fuel travel one of two paths through the State economy. Some of the dollars are spent in the purchase of cordwood. During 1979, 369,000 cords of wood were purchased by 176,000 Maine residents. The average price per cord (reflecting purchases of all forms of wood) was $49. Conservatively increasing the volume of wood purchased and the average price per cord to reflect increases since the survey dates, the value of cordwood purchases during 1980 is estimated to be at least $24 million. This was paid by residents to the wood processing and harvesting industry, which in turn spent a high percentage of its gross income on the employment of local labor. The value of cordwood purchases by Maine residents represents less than 32 percent of all dollars saved through wood energy substitution.

Most remaining dollars saved by substituting wood heat effectively increase household buying power. Some are spent to purchase wood-burning stoves and wood-harvesting equipment. Most of the remaining $52 million were spent by residents for a broad spectrum of household purchases, from food, clothing, and durables to vacations. These expenditures benefit local economies much more than expenditures for fuel oil. Dollars paid to a local fuel oil distributor are largely sent out of the State in exchange for refined petroleum. Dollars spent for locally produced goods or services are often respent locally by the person supplying those goods or services, multiplying the effect of the original purchases.

Changes in Conventional Energy Demand

Wood has emerged as a major source of energy for the residential sector, considerably lowering demand for fuel oil and electricity. Maine residents use 24 percent of all energy consumed in the State whereas, nationally, only 21 percent of energy is consumed by residences. 7/ This definition of the residential sector excludes gasoline used in automobiles. The U.S. Department of Energy estimates that Maine households demanded 58 trillion Btu's during 1978, and that petroleum provided 81 percent of this. However, the Department of Energy does not collect or include data on residential wood energy consumption.

7/ Residential sector consumption estimates are based upon 1978 data from the State Energy Data Report, U.S. Dept. Energy, Energy Information Adm. Apr. 1980, revised to correct overestimation of LPG.

Considered in the context of available Department of Energy data, wood energy constitutes 24 percent of the total energy demanded by Maine residences, with petroleum providing 62 percent (table 19). The energy content of the wood demanded by Maine households during the winter of 1979-80 is estimated at 14.6 trillion Btu's according to data provided by the 1980 Maine fuelwood survey (table 20).

Table 19--Energy demanded by residences, by fuel type, 1980, Maine

Energy form	Energy demanded 1/	Portion of all energy demanded
	Trillion Btu's	Percent
Petroleum	37.4	62
Natural gas	.6	1
Electricity	8.1	13
Wood	14.6	24
Coal	.03	--
Total	60.7	100

Note: -- = negligible amount.

1/ Estimates of residential consumption of conventional fuels are based upon the State Energy Data Report, U.S. Dept. Energy, Energy Information Adm. Apr. 1980, p. 385. Estimates are revised to correct for overestimation of LPG consumption and to remove generation and transmission losses included only for electrical energy. Residential electrical consumption as tabulated by DOE includes an additional 25 trillion Btu's. Approximately 8 percent of the indicated wood energy in Maine is burned in fireplaces and provides little useful energy.

Wood burns at lower efficiencies than conventional fuels and therefore produces less useful energy per Btu of fuel. More efficient wood-burning devices would help households now using wood heat to consume less wood, but would also encourage more households to convert to wood heat. The Maine wood conversion rate of 0.41, which resulted from deriving 6 trillion Btu's of space heat from burning wood with a heat content of 14 trillion Btu's, is much higher than that obtained by residents of most States. This high conversion rate is associated with the high portion of wood being burned in relatively high-efficiency equipment.

Table 20--Energy from wood combustion in residences, by household group, winter, 1979-1980, Maine

Household group	Estimated volume of wood burned	Energy content of wood burned 1/	Wood-burning efficiency	Useful energy from wood	Equivalent fuel oil displaced 2/
	Cords	Trillion Btu's	Percent	Trillion Btu's	Mil. gals.
Owner occupant	627,496	12.56	43	5.42	60.1
Using only fireplace	53,288	1.08	10	0.11	1.18
Using open wood stove	134,938	2.70	30	0.81	8.98
Using airtight wood stove	332,232	6.64	50	3.32	36.85
Using a wood furnace	107,038	2.14	55	1.18	13.06
Rental occupant					
Burning wood	47,588	.95	41	.39	4.32
Second and seasonal homes burning wood	56,061	1.12	3/ 17	.20	2.18
Total	731,145	14.63	41	6.01	66.6

Note: -- = insufficient sample.

1/ Cordwood measures in Maine are for closely stacked wood which often is hardwood, cut to stove length and split. Such wood, well seasoned, can provide 20 million Btu's per cord on average.

2/ Energy per gallon set at 138,700 Btu's per gallon or 5.825 million Btu's per barrel. Oil-burning efficiency assumed at 65 percent. The conventional fuel savings estimated by survey respondents is well above this estimate which is calculated upon the basis of volume of wood burned. This estimate does not include savings in conventional energy which are correlated with use of wood-burning equipment, such as lowered thermostat settings and zonal heating.

3/ Efficiency for mixed appliances in second homes assumed to be 17 percent.

Wood used in Maine residences displaces an equivalent of 67 million gallons of fuel oil (table 20, col. 5). This figure reflects the volume of fuel oil which would have been displaced by the volume of wood burned if wood had been substituted only for fuel oil. While a portion of this displaced energy is provided by other conventional fuels, fuel oil is by far the most common conventional fuel used in Maine residences (table 21).

Table 21--Conventional fuel available to homeowners for space heating, 1980, Maine 1/

Fuel	Households
	Percent
#2 fuel oil	75
Electricity	12
Natural gas	2
Propane	1
Kerosene	1
Total	2/ 91

1/ Calculated upon a sample base of 473 homeowners.
2/ Households heating only with wood and which have no alternative fuel available in the dwelling account for 9 percent of all homeowners.

Fuel oil and electricity represent the majority of the conventional energy being displaced by wood energy both because they are available to 93 percent of the households, and because they are relatively higher in cost per unit of energy. Analysis of two questions in the 1980 survey determined that 82 percent of the homeowners had fuel oil available for use. When asked to identify the fuel which "now provides most of the space heat for your family's residence," 35 percent of homeowners identified wood. This response, identifying households using wood as a "primary" space heating fuel, includes 71 percent of those using an airtight wood stove and 97 percent of those using a central wood-fired heating system.

The 35 percent of homeowners who identified wood as providing most of their space heat generally compares with the 51 percent who indicated use of a wood-burning stove or central wood-fired heating system. Of those homeowners using wood-heating equipment, 17 percent indicated no use of conventional fuel for supplementary heat.

The Maine 1980 survey shows the heavy reliance on fuel oil and electricity as primary heating fuels (87 percent) by Maine residents (table 21). This is a substantially larger proportion than primary fuel consumption in the Northeastern States (U.S. Department of Energy). 8/ In these States, the primary fuels of fuel oil and kerosene supply 47 percent of dwellings. However, natural gas, which can be delivered at low cost by pipe to more densely settled areas, supplies 41 percent of households. Electricity supplies 11 percent and propane supplies 1 percent. This relationship explains why the residents of Maine, on the average, substitute more wood energy for conventional fuels than the residents in the Northeast.

Cordwood Demand and the Forest Resource

The relationship between the forest resource and cordwood demand gives rise to two central questions:

1. Will the satisfaction of fuelwood demand lead to overharvesting or deterioration of the resource?

2. Will the supply of cordwood constrain the increasing use of cordwood as a substitute for conventional fuels?

Residents obtain cordwood both by purchasing and by selfcutting. Analysis must consider these two sources separately as well as their interaction. The wood supplied by residents harvesting for their use largely depends on privately owned small woodlots, which are usually a part of the residence. A considerable percentage of these woodlots are not large enough to provide all of the wood required by the household on a sustainable yield basis. As a result, after several years of harvesting trees considered excess stock, many residents may begin to purchase an increasing portion of their cordwood to prevent destruction of their woodlots.

A proportion of the cordwood marketed is sold by enterprises whose primary employment is in supplying either pulp or timber products. These enterprises are able to separate trees and sell them to the markets that represent the highest valued use for their product. These firms are competitive at current

8/ In addition to New England, States in this region include Maryland, Delaware, Pennsylvania, New York, and New Jersey.

market prices. Integration of wood products within a harvesting operation makes cordwood production dependent upon the harvesting for other wood products since a smaller proportion of profit is derived from fuelwood. This relationship is limited to current price relationships.

Production efficiency is also limited by the size of woodlots. Small woodlots, which characterize most of New England, result in higher transportation costs of harvesting equipment to the site, and higher administrative costs to the harvester. Small woodlot owners are usually more concerned with environmental controls, which increases the cost of harvesting (2). Quality of most timber stands in the State is relatively poor. Much of the past timber harvesting resulted in highgrading, wherein the best trees were harvested and the poorest were left. Remaining trees became parent stock for much of the present tree populations and, as a result, present stands are of lower quality, which decreases production efficiency in terms of annual growth. Cordwood use and the resulting market demand provide an opportunity to harvest this lower quality timber and could improve overall quality of remaining timber stands.

Transportation of cordwood also affects local supply. In areas which have a few large woodlots and a limited number of sawmills that use cordwood co-products, local residential demand raises cordwood prices and imported wood provides much of the supply. Cordwood is commonly transported up to 100 miles to reach higher priced markets. Many densely settled areas of New England that possess limited forest resources now burn more wood than the forests within the area can supply in the long term, given current management practices.

Cordwood in these areas of intense use will eventually be supplied from two sources: wood locally available on a sustainable basis and wood purchased from suppliers operating in a much larger market region.

Several broadbrush efforts have been made to estimate the potential supply of wood energy within the next 20 years. These estimates largely depend upon the area of land in forest and current forest conditions (table 22). An estimate of annual available biomass for Maine was made by the Biomass Subcommittee of the New England Energy Congress (4). That estimate included a renewable yield (cull increment, annual mortality, annual thinning of poletimber stands, mill residues, and logging residues) and a nonrenewable yield (land clearing, existing cull, and one-time thinning) which would reduce the overstocked forests over 20 years. The estimate of total wood energy potential per year in Maine is given by the final

report of the New England Energy Congress as 432 x 10^{12} Btu's, which is an equivalent of 18 million cords per year (4). The committee also noted the present lack of an established supply network as the major limit to biomass supply. Another estimate of the annual energy potential that could be derived from Maine's biomass was made by Glidden and High. This estimate which includes rough and rotten standing stock depleted over 20 years, annual cull increment, annual mortality, annual net growth, logging residues, and manufacturing residues amounted to 442 x 10^{12} Btu's (3).

Table 22--Forestland use in New England

State	Commercial forestland	Productive reserved	Unproductive 1/	Proportion of land in forest
	1,000 acres			Percent
Connecticut	1,806	2/ 30	25	69.7
Maine	16,894	221	634	89.7
Massachusetts	2,798	104	50	58.9
New Hampshire	4,692	2/ 55	238	86.2
Rhode Island	395	9	--	60.2
Vermont	4,430	2/ 44	20	75.7
Total	31,015	463	967	80.5

Note: -- = negligible amount.
1/ Incapable of producing 20 cubic feet per acre per year of industrial wood (all roundwood products except fuelwood).
2/ Includes some acreage used for Christmas tree production.
Source: U.S. Forest Service resource bulletins NE-26, NE-36, NE-43, and NE-46.

The 1980 residential demand from within the State is estimated at 874,000 cords (acquired during 1980). Industrial wood energy demand is over 800,000 cords per year, largely supplied by mill residue and manufacturing wastes. Current export demand is roughly estimated at 50,000 cords per year, but this figure could increase considerably. These approximate figures suggest that Maine's current wood energy demands are well below its current wood energy supply potential. However, this relationship must be evaluated relative to the rapid growth of wood energy adoption and the availability of the potential supply.

Safety and Wood Energy

Resurgence of wood energy has resulted in an increased incidence of chimney and housefires. Wood-burning respondents indicated whether they had experienced a fire within the last 6 years and how the fire started. As a survey of all households, rather than a survey focused on households experiencing a hazardous event, the survey is useful in estimating the frequency of fires. Other surveys made by Shelton (7) and Peacock (6) have focused on those experiencing fires. These efforts provide a better sample for understanding causes of housefires related to use of stoves and furnaces fueled by wood.

Over 1 percent of Maine households experience a housefire associated with the burning of firewood each year. Six percent of households burning wood (36 observations of 560 sample points) experienced a housefire associated with wood use during the 6-year period (1973 to 1979). For homeowners using an airtight wood stove, 7 percent (14 of 209) experienced such a fire during the same period. Most of the fires (32 of 41) started as a chimney fire. The frequency of housefires caused by burning wood in Maine is the greatest in New England, well above the 5 percent of all New England wood-burning households that have experienced such a fire during the 6-year period.

Some 68 percent of those households using airtight wood stoves had installed a smoke detector; only 53 percent of nonwood-burning households had installed them. The installation rate of smoke detectors, together with the fact that 20 percent of households using airtight stoves clean their chimneys less than once a year, suggest that this group of wood-burning households recognizes the increased safety problems associated with wood energy.

Over 70 percent of wood- or coal-related chimney or housefires result from faulty installation, according to one study (7). Poor maintenance or inadequate clearance caused 16 percent of such fires, operator error caused 11 percent, and faulty equipment caused 2 percent. Peacock confirms faulty installation as the primary cause of fires, and lists nine major causes of accidents related to wood burning (6):

1. Use of unvented equipment inside a dwelling.
2. Installation of wood-burning equipment too close to combustible framing and furnishings.
3. Placement of flammable solids and liquids too close to wood-burning equipment.
4. Use of flammable liquids to kindle a fire.
5. Overloading of wood-burning equipment, leading to operation well beyond design limits.

6. Ignition of clothing or other fabrics during loading, unloading, cleaning, or use of wood-burning equipment.
7. Contact burns received from hot surfaces of wood-burning equipment.
8. Use of defective or improper chimneys.
9. Ignition of creosote and carbon deposits on the inside of chimneys leading to chimney fires.

Peacock reported that 94 percent of the accidents occur in one- and two-family dwellings. About 55 percent of the accidents were related to the wood-burning unit itself, 35 percent resulted from malfunction of the chimney, and 10 percent resulted from the chimney connectors on freestanding stoves.

A University of Maine Cooperative Extension study interviewed 100 fire departments in Maine to ascertain the causes of the recent increase in wood-burning fire incidents (8). The study found that an increase of 60 percent in wood heat related fires occurred between 1979 and 1980, and that 86 percent of these fires originated in chimneys. Wood fires that caused structural damage increased from 417 in 1979 to 551 in 1980 (32 percent increase). In towns with population of less than 5,000, the usual causes of fires were poor burning practices and poor chimney maintenance. In the larger, more urban towns, the major causes of wood heat related fires were from faulty installations (not enough clearance between stove and flammable surfaces).

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APPENDIX I:
SURVEY METHODS 1/

Discussion of Survey Bias

Telephone surveys of Maine households were conducted in 1979 and 1980 as a means to estimate the volume of cordwood consumed by residences during the winters of 1978-79 and 1979-80. Telephone surveys, like other types of surveys, have survey bias. Bias is the difference between the estimated value of a statistic obtained by random sampling and the true value. There are certain conditions giving rise to bias in any survey technique; the result may be an estimate (for example, volume of cordwood burned) that is much different than the true value (in this example, volume of cordwood actually burned). There are a number of survey biases associated with telephone surveys, as well as biases that result from "uncheckable" information. During the design phase, eight potential forms of survey bias were identified, and where necessary, steps were developed to insure minimum influence by these biases. These sources of survey bias were:

1. Households without telephones could not be interviewed. Thus, there was no means to ascertain whether their wood-burning practices differed from those households interviewed.

2. Households with unlisted telephone numbers could not be selected for interview since published telephone lists were used as the surveyed population.

3. Hard-to-reach or not-at-home households may burn less wood since no one is at home during typical working hours.

4. Households that refuse to be interviewed create a possible source of bias.

5. Households that refuse to answer individual questions also create a possible source of bias.

6. The system through which volunteer enumerators were chosen in several States resulted in a potential source of bias in that one geographical area may have had a higher number of sample points and thus may have created an over-weighting of data from that area.

1/ A detailed description of methods will appear in a forthcoming report (see text footnote 2).

7. In some States, the wood use of rental households not paying separately for their own heating fuel was estimated with data from other States where this household group was interviewed.

8. A final form of bias is either the under- or over-estimation of cords reported by each responding household.

In order to insure precise estimates steps were taken to first identify whether the potential source of bias was present and whether the bias would have a significant impact upon estimated statistics. Coefficients were developed to adjust the gross estimates derived from survey analysis in order to mitigate the bias impacts. Methods employed in developing the adjustment coefficients included subsurvey, resurvey, and stratification of response. The identified potential biases were analyzed as follows:

1. Households without telephones: This may be the least understood source of bias since the use of a telephone survey precludes the inclusion of this houshold group, and as a result, it is impossible to estimate the volume of fuelwood that this group consumes. However, given the fact that a very small percentage of households are without phones, that they tend to be located in rural areas, and that there is no evidence that this household group has something other than a random distribution of wood-burning characteristics, it was assumed that the bias resulting from not interviewing this group was minimal. Any bias stemming from this group would probably result in a slight, insignificant underestimation of total cordwood consumption. Similarly, presence of households with more than one telephone may result in bias, but this group's wood use is expected to be similar or slightly less than that of the one-telephone household.

2. Households that have unlisted (unpublished) telephone numbers may constitute up to 10 percent of households. Generally, this group of households tends to be concentrated in urban areas and to be heavily female-headed. In order to estimate the potential amount of bias stemming from this group, a subsurvey was conducted in Maine to determine if this group was significantly

different in their wood-burning characteristics. An analysis of a "plus-one digit" dialing survey suggested little bias from this group. 2/

In addition, Clyde L. Rich, who has investigated this problem notes:

> Because many of the differences are small and the non-published population is small, samples drawn from telephone directories have virtually the same demographic characteristics as samples which include non-published numbers. 3/

3. Hard-to-reach household bias was estimated by analyzing separately the data derived from households which responded on the third or later call. This analysis indicated that a significant bias was present. As a result, gross cordwood volume estimates were reduced by 9 percent.

4. Bias resulting from households that refused to participate in the survey was estimated by recalling them. On the recall, it was explained why they were being called back. Recalls were very effective in that very few of the households declined to answer the questions. Analysis of that data indicated that no bias was present.

5. Households that refused to answer specific questions contributed no bias in that their refusals were centered upon questions dealing with socioeconomic information (age and sex of head of household, household income, etc.) and not upon questions dealing with household wood-burning characteristics.

6. Through geographically stratifying survey results, bias resulting from an uneven distribution of sampled households was negated.

7. Except in Vermont, household renters who did not pay for their heat separately from their rental payment were not surveyed because:

2/ "Plus-one digit" dialing refers to a process where the last digit of a published number is increased by one, and then called.

3/ Clyde L. Rich, "Is Random Digit Dialing Really Necessary?" J. Marketing Research, Aug. 1977.

a. The vast majority are apartment dwellers with little opportunity to use wood.

b. Unless heating costs are separated from the rental payment, such households have little economic incentive to convert to a nonconventional fuel.

The minimal wood use of this group was estimated for the other New England States through use of data from the Vermont survey.

8. Potential bias from faulty reporting of cordwood volumes was approached through a double survey which compared results of the standard questionnaire with one which contained an indepth discussion of the cord and other wood measures. That survey took place in the five counties surrounding Burlington, Vermont. An overestimation of 9 percent occurred. Thus, gross estimates less the adjustments for hard-to-reach households were reduced by an additional 9 percent. While it is certainly recognized that a ground-truth check would have been ideal, budget and time constraints precluded such an effort. 4/

Survey Sample Design

The six States had different spatial objectives relative to the survey. Massachusetts, for example, wished to estimate wood use on a county-by-county basis, whereas Rhode Island and Vermont wished to have data only on a Statewide basis. Other States wished to collect data that would result in estimates for one or more regions. All States collected data from enough sample points to permit a rigorous statistical assessment of residential wood use at the State level. (App. table 1).

Telephone numbers were generated in such a way as to assign each household an equal probability of being surveyed. The selection procedure used telephone books to find noncommercial household telephone numbers in a randomly started, standardized manner. Selected numbers were pursued, within reason, according to a series of call-back rules until a survey was completed. If any number could not be surveyed, it was replaced with another number found by continuing the standardized procedure.

4/ Ground-truth check is described as follows: A subsample of the sampled households is asked how many cords presently in inventory. Then, the interviewer would travel to those households and actually measure the wood stacks to determine accuracy of household volume estimates.

Appendix table 1--Total sample collected, by State, 1979

State	Number of usable questionnaires
Maine	1,152
New Hampshire	813
Vermont	555
Massachusetts	2,359
Rhode Island	301
Connecticut	446
Total	5,626

Survey Precision in Maine

Interviewing in Maine to determine residential wood use during the winter of 1978-79 resulted in a stratified sample of 1136 respondents (App. table 2). Stratification by tenure and county allowed use of census data to correct for sampling bias. Use of stratification precluded use of 16 responses which had not recorded all information required to stratify. Combination of survey and census data resulted in the estimate of households by type of wood-burning apparatus (App.II). Precision of this estimate is determined by the percentage of all respondents of a strata using a form of wood-burning apparatus and the sample for that strata.

Appendix table 2--Stratified sample of household respondents, Maine, 1979

Group	Sample size
Second or seasonal home occupant not burning wood	15
Second or seasonal home occupant burning wood	18
Rental household with heat included not burning wood	25
Rental household with heat included burning wood	5
Rental household paying for heat separately not burning wood	102
Rental household paying for heat separately and burning wood	27
Owner-occupant household not burning wood	408
Owner-occupant household using an open fireplace	67
Owner-occupant household using an efficient fireplace	24
Owner-occupant household using a traditional open wood stove	168
Owner-occupant household using an airtight wood stove	215
Owner-occupant household using a central wood-fired heating system	62
Total	1136

Reported consumption of cords by type of apparatus allows estimation of the residential use of wood based upon the above estimated household group populations (App. table 3). Reported volumes burned are corrected for identified faulty response bias associated with poor understanding of the cord measure. The resulting average volume burned by apparatus type has a precision or standard error related to the distribution of reported responses together with the sample size.

Appendix table 3--Precision of average volume burned by apparatus for owner-occupant households, Maine, winter, 1978-79

Apparatus	Total respondents	Average volume burned per household	Standard error of average	Sample for average volume
	Number	----Cords----		Number
Open fireplace	67	1.66	.17	59
Efficient fireplace	24	2.45	.46	23
Traditional wood stove	168	3.32	.17	155
Airtight wood stove	215	3.92	.16	204
Wood furnace (combinations incl.)	62	5.12	.41	57

The resulting estimate of residential wood use has a level of precision or standard error which is a function of both the standard error of the percentage of households within a group and the standard error of the average volume burned by that group. The standard error for the Maine Statewide estimate of cordwood use by residents during the winter of 1978-79 is 28,737 cords or 5 percent of the 575,036 cords burned (App. table 4).

Appendix table 4--Standard errors for estimates of fuelwood burned in Maine during the winter of 1978-79

Wood-burning group	Andros	Aroost	Cumb	Frank	Hancoc	Kenneb	Knox	Lincol	Oxfrd	Penobs	Piscat	Sagada	Somers	Waldo	Washin	York	Std. Error for groups
	cords																
Second or Seasonal home	461	909	3061	585	1818	1449	715	1215	1156	1029	1111	254	566	691	739	3055	5702
Rental household with head included	1126	756	2130	149	244	886	245	110	336	1108	90	216	304	158	165	1119	3179
Rental household paying separately	1105	742	2089	146	240	869	240	108	330	1087	88	212	298	155	162	1097	3118
Owner occupant using only an open fireplace	1678	1890	2641	374	963	903	630	1379	2248	6295	116	510	0	642	900	1841	8192
Owner occupant using a traditional wood stove	3278	7643	4424	1920	1746	4844	1365	1701	2493	6394	2318	1646	2338	2077	4951	2665	14842
Owner occupant using an airtight wood stove	5459	2400	6133	4669	3313	6646	1733	2010	5354	6937	3417	1147	7395	2054	2529	3128	17945
Owner occupant using a central wood furnace	2870	4442	4166	2888	5050	4996	976	1505	1299	3967	3489	0	2066	1262	3408	2967	12809
Standard errors for counties	7369	9456	10031	5852	6624	9852	2616	3550	6517	12159	5521	2108	8058	3326	6628	6393	28737

APPENDIX II: TABLES OF BASIC FINDINGS

The following tables present basic findings of the Maine survey of residential wood use during the winter of 1978-79. Information on wood burned, purchased, and harvested by households is comparable to estimates to be published for all other New England States. Together, these estimates constitute an integrated estimate of residential wood use by county for New England.

The household groups used in appendix tables 5 and 6 are defined as follows:

Group 1 - Second or seasonal homes not burning wood
Group 2 - Second or seasonal homes burning wood
Group 3 - Rental household with heat included not burning wood
Group 4 - Rental household with heat included burning wood
Group 5 - Rental household paying for heat separately not burning wood
Group 6 - Rental household paying for heat separately and burning wood
Group 7 - Owner-occupant household not burning wood
Group 8 - Owner-occupant household using an open fireplace
Group 9 - Owner-occupant household using an efficient fireplace
Group 10 - Owner-occupant household using a traditional wood stove
Group 11 - Owner-occupant household using an airtight wood stove
Group 12 - Owner-occupant household using a central wood furnace

The household groups used in appendix tables 7 and 8 are defined as follows:

Group 1 - Second or seasonal homes not burning wood
Group 2 - Second or seasonal homes burning wood
Group 3 - Rental household with heat included not burning wood
Group 4 - Rental household with heat included burning wood
Group 5 - Rental household paying for heat separately not burning wood
Group 6 - Rental household paying for heat separately and burning wood
Group 7 - Owner-occupant household not burning wood
Group 8 - Owner-occupant household using only a fireplace
Group 10 - Owner-occupant household using a wood stove or furnace

Appendix table 5--Number of households stratified by wood-burning category, apparatus type, and county, Maine, winter, 1978-79

	ANDROS	AROOST	CUMBER	FRANKL	HANCOC	KENNEB	KNOX	LINCOL	OXFORD	PENOBS	PISCAT	SAGADA	SOMERS	WALDO	WASHIN	YORK
GROUP 1	643	1268	4269	815	2535	2020	998	1694	1613	1435	1550	354	790	964	1031	4260	26240
GROUP 2	772	1522	5122	979	3042	2425	1197	2033	1935	1722	1860	425	947	1156	1238	5113	31487
GROUP 3	4348	2919	8223	574	943	3421	945	426	1298	4278	347	835	1174	610	637	4319	35298
GROUP 4	870	584	1645	115	189	684	189	85	260	856	69	167	235	122	127	864	7060
GROUP 5	6453	4333	12203	852	1400	5077	1403	632	1927	6349	515	1239	1742	905	945	6410	52384
GROUP 6	1708	1147	3230	226	371	1344	371	167	510	1681	136	328	461	240	250	1697	13866
GROUP 7	9225	8919	21703	1050	4912	10276	4214	1756	5610	15358	1081	2924	5309	2375	3430	15119	113260
GROUP 8	2406	1784	5976	700	893	822	624	675	510	4065	540	1096	0	570	980	3725	25368
(N/A)																	
GROUP 10	1604	7581	6605	1749	893	3699	1795	1081	1785	5420	540	2010	1225	1805	1960	4820	44574
GROUP 11	5214	892	8493	2099	2233	6166	2107	3242	3825	4517	1621	914	4492	2090	2940	4382	55226
GROUP 12	802	1784	2202	1050	2680	2466	468	675	255	1355	1081	0	408	665	980	1534	19404
TOTALS	34045	32732	79671	10208	20091	38401	14311	12468	19528	47037	9340	10291	16783	11500	14519	52243	423168

Appendix table 6--Volume of wood burned by residential sector, in cords, Maine, winter, 1978-79

	ANDROS	AROOST	CUMBER	FRANKL	HANCOC	KENNEB	KNOX	LINCOL	OXFORD	PENOBS	PISCAT	SAGADA	SOMERS	WALDO	WASHIN	YORK
GROUP 2	1374	2709	9120	1742	5416	4317	2132	3619	3446	3066	3312	757	1687	2059	2204	9102	56061
GROUP 4	2160	1451	4086	285	469	1700	470	212	645	2126	172	415	583	303	316	2146	17538
GROUP 6	4628	3107	8753	611	1004	3641	1006	454	1382	4554	369	888	1249	649	678	4597	37572
GROUP 8	4899	3632	7146	1424	1818	1674	1551	1740	1038	8277	1100	1044	0	1133	1995	5352	43831
(N/A)																	
GROUP 10	4152	20250	16700	4490	1664	10042	5722	4027	4730	18157	2237	4313	3889	7514	8521	9480	134019
GROUP 11	17919	3102	26183	10285	5917	23318	7544	10495	18099	17768	6174	2270	25363	8730	6097	10992	200456
GROUP 12	3735	8306	10252	4887	12477	11484	2180	3145	1187	6310	5032	0	1902	3096	4563	7142	85699
TOTALS	38867	50557	82239	23726	28765	56176	20605	23700	30528	60257	18396	9686	34673	23984	24364	49012	575053

Appendix table 7--Volume of wood purchased by the residential sector, in cords, Maine, winter, 1978-79

	ANDROS	AROOST	CUMBER	FRANKL	HANCOC	KENNEB	KNOX	LINCOL	OXFORD	PENOBS	PISCAT	SAGADA	SOMERS	WALDO	WASHIN	YORK
GROUP 2	1340	2641	8891	1698	5280	4209	2078	3528	3359	2989	3228	737	1644	2007	2149	8874	54651
GROUP 4	327	220	619	43	71	257	71	32	98	322	26	63	88	46	48	325	2656
GROUP 6	2680	1799	5068	354	581	2109	582	263	800	2637	214	514	723	376	393	2662	21755
GROUP 8	2752	2040	7027	800	1022	940	714	773	583	4650	618	1254	0	652	1121	3707	28653
GROUP 10	13322	33984	29683	9271	16219	15698	9120	9317	13754	16412	9277	2905	20545	7706	15013	13081	234307
TOTALS	20421	40684	51287	12166	23173	23212	12566	13913	18594	27009	12363	5474	23001	10787	18723	28648	342022

Appendix table 8--Volume of wood harvested by households for own use, in cords, Maine, winter, 1978-79

	ANDROS	AROOST	CUMBER	FRANKL	HANCOC	KENNEB	KNOX	LINCOL	OXFORD	PENOBS	PISCAT	SAGADA	SOMERS	WALDO	WASHIN	YORK
GROUP 2	128	252	848	162	504	402	198	337	321	285	308	70	157	192	205	847	5215
GROUP 4	1152	774	2179	152	250	907	250	113	344	1134	92	221	311	162	169	1145	9355
GROUP 6	2308	1550	4364	305	501	1816	502	226	689	2271	184	443	623	324	338	2293	18735
GROUP 8	2287	1695	5451	665	849	781	593	642	485	3863	513	1042	0	542	931	3091	23031
GROUP 10	12987	17576	33238	11912	3806	28726	9228	14177	8136	36713	9400	4199	14871	12756	3648	20391	241764
TOTALS	18862	21847	46081	13196	5909	32631	10772	15494	9974	44266	10498	5975	15962	13975	5292	27767	298500

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